Pluto Hop, Skip, and Jump

Completed Technology Project (2017 - 2018)

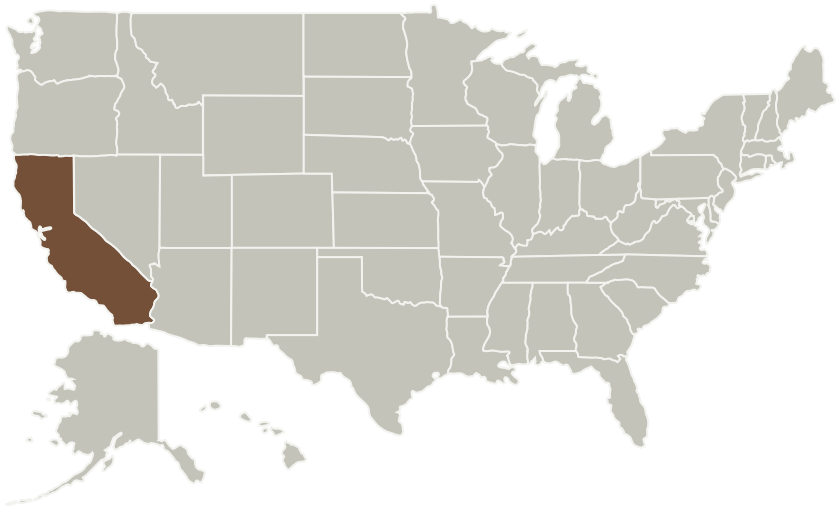
Project Introduction

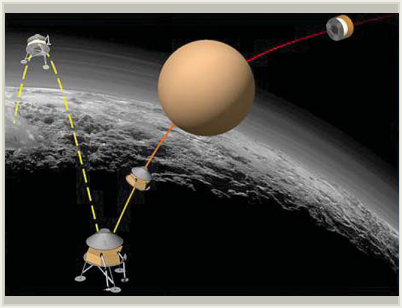
Imagine a craft that could enter Pluto's atmosphere at 14 km/s and deliver a 200 kg lander to the surface using aerodynamic drag and just a few kg of propellant. Pluto's surface pressure is just 10 millionths of Earth's, but its atmosphere is about 7 times higher than Earth's and its volume is about 350 times the volume of Pluto itself. Over a several hundred kilometer entry distance, this ultra-low ballistic coefficient craft can dissipate over 99.999% of its initial kinetic energy, resulting in a terminal velocity comparable to or less than past planetary landers or rovers. With this architecture, the total propellant requirement for landing on Pluto is less than 3.5 kg! After making science measurements at its initial landing site, the lander switches to hopper mode, taking advantage of the low gravitational acceleration (0.063 gee) and a modest propellant store to literally hop, skip, and jump around the surface, sometimes kilometers at a time, investigating features of interest. The proposed concept would enable in-situ surface science at Pluto with low overall mass, a reasonable cost, and in a timeframe of about 10-15 years.

Anticipated Benefits

The proposed concept would enable in-situ surface science at Pluto with low overall mass, a reasonable cost, and in a timeframe of about 10-15 years.

Primary U.S. Work Locations and Key Partners





Potential Pluto Hop, Skip, and Jump mission. Credits: Benjamin Goldman

Table of Contents

Pluto Hop, Skip, and Jump

Completed Technology Project (2017 - 2018)

Organizations Performing Work	Role	Type	Location
Global Aerospace Corporation	Lead Organization	Industry	Irwindale, California

Primary U.S. Work Locations
California

Project Transitions

April 2017: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Global Aerospace Corporation

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

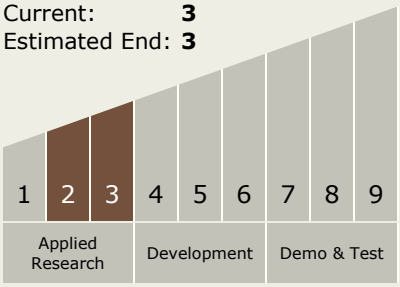
Eric A Eberly

Principal Investigator:

Benjamin Goldman

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Pluto Hop, Skip, and Jump

Completed Technology Project (2017 - 2018)

January 2018: Closed out

Closeout Summary: This is the Final Report from Global Aerospace Corporation on this NIAC effort (Grant Nos.: NNx17AJ71G and 80NSSC18K0062) to develop the Pluto Hop, Skip, and Jump mission concept. We sought out to establish the feasibility of using a large inflatable drag device to decelerate and land on Pluto from interplanetary speed (~14 km/s) using only the Pluto atmosphere and just a few kilograms of propellant. The design and analysis efforts in Phase I indicated that this is feasible. Aerodynamic heating and loads were found to be orders of magnitude less than typical planetary entries due to the ultra-low ballistic coefficient craft and the low density and large scale height of the Pluto atmosphere. The deceleration system is capable of delivering a 200-kg lander-hopper to the surface or inserting an orbiter of a similar mass using aerocapture. Mission analysis work led to a reference mission with Earth launch in 2029, Jupiter assist in 2030, and Pluto arrival in 2040. Global Aerospace Corporation and its research partner, ILC Dover, have documented in this report the results of the design and analytical modeling efforts during the contract period (9 May 2017 - 9 February 2018). Key accomplishments include: •Refined atmospheric models using the most recent New Horizons measurements and established the system-level requirements for a reference mission design, •Performed interplanetary trajectory analysis to select a reference launch and arrival condition and analyzed Pluto arrival approach conditions to enable a lander mission, •Used planetary aeroassist simulations to study the Pluto entry environment conditions including convective heating, g-loads, dynamic pressures, and evaluated the effect of atmospheric variation on the decelerator performance, •Performed approach and landing analysis to determine the possible Pluto landing site locations based on the arrival geometry, and also performed an aerocapture analysis to evaluative feasibility of orbit insertion, •Performed static structural, dynamic aeroelastic, CFD aerothermodynamics, and thermal analysis leading to a conceptual decelerator design, •Developed a feasible materials solution for the decelerator envelope using conventional materials and softgoods fabrication techniques, generated an envelope patterning design, developed a load-distribution scheme, and generated an envelope system mass breakdown, •Designed a lander-hopper payload, selected science payload components, evaluated hop performance at the surface, and generated a mass breakdown, •Developed the integrated system conceptual design and mass breakdown.

Closeout Link: https://www.nasa.gov/directorates/spacetech/niac/2017_Phase_I_Phase_II/Pluto_Hop_Skip_Jump

Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
  - TX09.2 Descent
    - TX09.2.1 Aerodynamic Decelerators

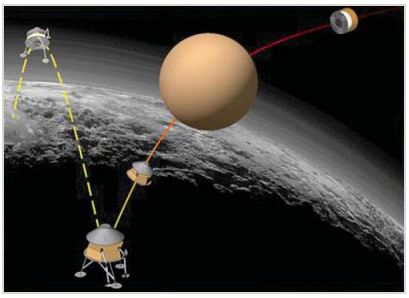
Target Destination

Others Inside the Solar System

Pluto Hop, Skip, and Jump

Completed Technology Project (2017 - 2018)

Images



Project Image
Potential Pluto Hop, Skip, and Jump mission. Credits: Benjamin Goldman
(https://techport.nasa.gov/image/102258)

Links

NASA.gov Feature Article
(https://www.nasa.gov/directorates/spacetech/niac/2017_Phase_I_Phase_II/Pluto_Hop_Skip_Jump)